McKNIGHT

Development of Sanitation And Sanitary Engineering

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THE DEVELOPMENT
OF
SANITATION AND SANITARY ENGINEERING

...BY...

William Asbury McKnight

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

WILLIAM ASBURY McKNIGHT

ENTITLED THE DEVELOPMENT OF SANITATION and SANITARY ENGINEERING.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

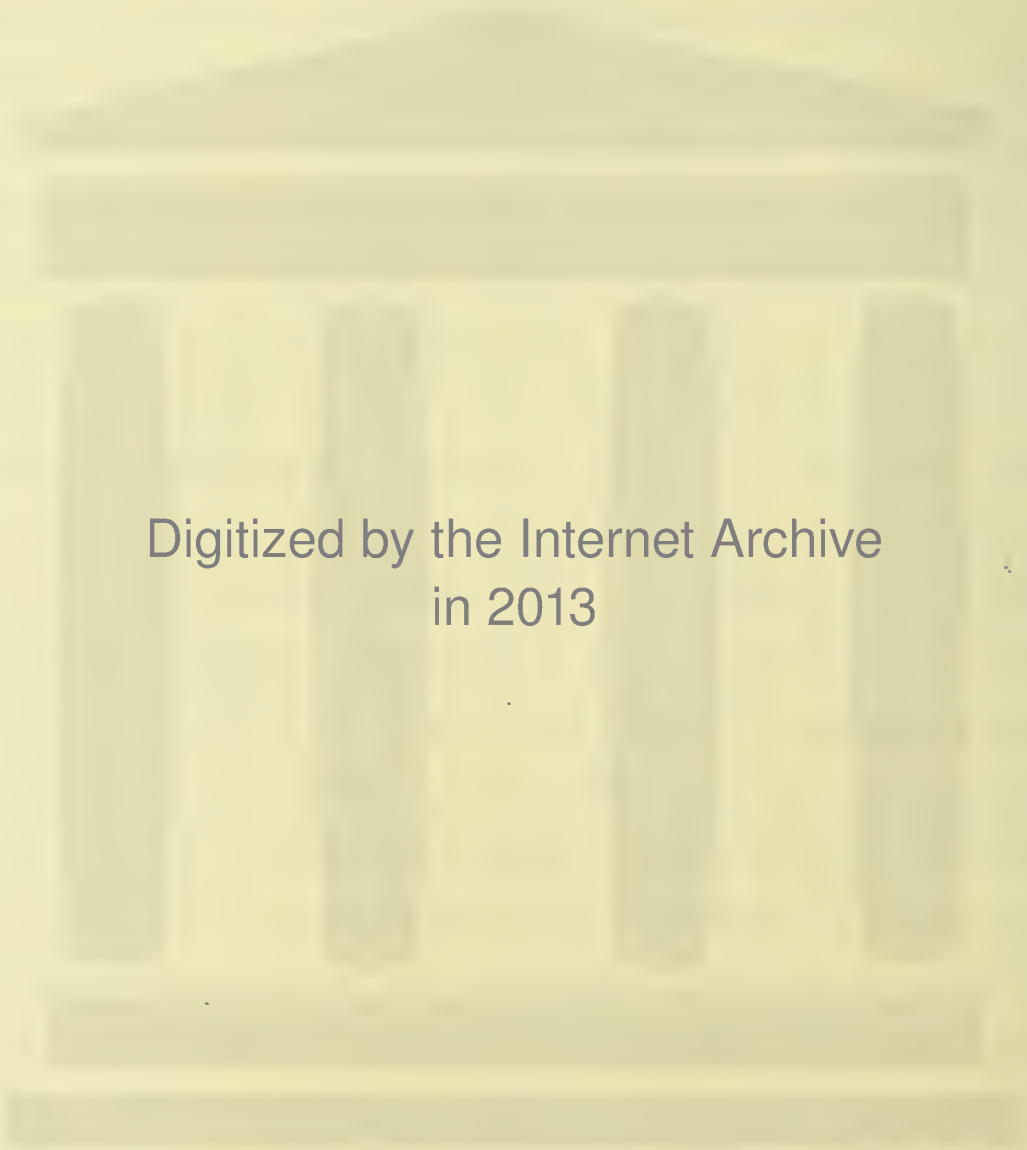
OF Bachelor of Science in Municipal & Sanitary Engineering.

A. N. Talbot

HEAD OF DEPARTMENT OF Municipal and Sanitary Engineering.

THE DEVELOPMENT OF SANITATION AND SANITARY ENGINEERING

Sanitation and sanitary engineering involves the construction and maintenance of works, methods of water and sewage purification, the improvement and control of conditions in cities, etc., by which the public health of communities and nations is promoted and disease prevented. The importance of the science is apparent. The truths which form the basis of sanitary science have been discovered by the medical profession, scientists, boards of health, and sanitary engineers. In almost all classes of society there is a great and growing interest in sanitation. Since people have learned that so great a proportion of the disease which affects humanity results from preventable causes, and that it is possible by judicious measures of sanitary reform so to reduce the death rate as materially to increase the average duration of human life, they have begun to appreciate the importance of sanitation. Its importance is very well expressed by a prominent English statesman, that "The greatness of a country is dependent more than anything else upon the physical constitution of its inhabitants, and everything which is done to improve the state of the public health forms the foundation for the strength, the power, and splendor of a nation."



The rapid development of modern sanitation began with the discovery of the germ theory of disease, teaching that those diseases arising from polluted water, contaminated air, bad food, impure soil, filth accumulations, and general neglect of cleanliness, are in a large measure preventable. The true foundation for all works of modern sanitary engineering is that pure air, pure water, pure soil, and pure food are essential to public health as well as to personal health.

Among the problems which confront the sanitary engineer, then, the following are the most important:

1. The provision of a pure and abundant water supply.

2. The provision of an adequate sewerage system for carrying away sewage, and the devising of methods for the purification and disposal of this sewage.

3. The securing of pavements for streets, and the maintenance of cleanliness on the same.

4. The provision of healthful food supplies, and a proper and efficient food inspection.

5. The enlargement of cities, and a partial reconstruction of their streets and thoroughfares.

In order to study the development of sanitation, it will be necessary to make a study of the conditions which obtain where sanitation is unknown, or practically unknown. In primitive conditions no attempt was made to insure a pure water supply, to drain the soil, or to provide any means for the collection and removal of waste matters. It is not necessary, however, to go back to these primitive conditions to find this

lack of consideration for such matters. From the fall of the Roman Empire to the end of the Middle Ages, according to James C. Bayles,(1) the people of Europe were unwashed. The terrible conditions of filth, disease, and misery are almost beyond the conception of people of today. In Paris and London and other large cities of Europe during the twelfth century, no attempts were made toward the securing of clean streets, and no attempts were made to govern the places of deposition of human excreta. James C. Bayles, in writing of these conditions in his book on "House Drainage and Water Service," quotes Rigord, physician to Philip Augustus, in speaking of the terrible conditions of the streets of Paris, as saying that one day when the King was walking to and fro in his audience chamber, he went to look out upon the view for recreation, and was overcome by the stench from the streets. (2) This stench resulted from the filth being stirred by the wheels of vehicles that were passing by. The cathedral itself was a common place of convenience, and when the King ordered a wall built around it to protect it from this, and ordered the streets paved, the order caused great populat dissatisfaction. The people did not want to be clean.

The conditions in London at this time were similar. One writer in speaking of the conditions there, said that in the streets around St. Paul's Church yard, "The horse manure was a yard deep." Public muck heaps were found upon every corner. The homes were filthy beyond description, and personal cleanli-

(1) Page 7 of his book on "Hygiene in Its Practical Relations to Health."

(2) For much of this information I am indebted to the work of James C. Bayles, "House Drainage and Water Service."

ness was a thing almost unknown. Most of the floors of the houses were of clay, covered with rushes. In many cases, that layer of rushes next to the clay was not removed once in twenty years, and in it was such a collection of foulness as we would expect only in a scavenger's cart. Common decency will not permit of a detailed account of the items of this filth.

These conditions are typical of those existing in all the larger cities of Europe. In all these cities the odors were horrible, and to disguise them perfumes were used and fragrant gums burned. The results of such conditions are inevitable, and the history of many cities show the severe price paid by the people for allowing them to exist. Let us notice, briefly, a few instances. The history of Chester, England, shows the result of this utter neglect of sanitary precautions. In 1507 sweating sickness in Chester was very severe for three days, ninety-one deaths resulting. There was a great plague and a recurrence of the sweating sickness in 1550. In 1603, a greater plague than had yet been experienced, occurred, 650 persons, 60 per week died, and 61 of other diseases. In 1604 a worse plague came upon the inhabitants of the city, 812 deaths resulting. Another plague followed in 1605, 1313 persons dying, and in 1649 a still worse plague ensued, there being 2099 deaths in the one year. Other plagues followed, but still the people did not remove the garbage heaps, clean the streets, improve their homes, nor form habits of personal cleanliness.

The jail disease was another disease much dreaded by all classes. The prisons were unsanitary, the cells being cold,

damp, and unventilated. The prisoner had no opportunity for exercise, and no chance to wash either his own clothing or his miserable bed clothing. When set at liberty, he often carried the terrible disease, called jail fever, to the people at large. Thus any one might be exposed, and when once started, it spread with great rapidity, and there was no known means of checking it. A specific instance was the Black Assize at Oxford, in 1577. A prisoner was brought from such a cell as has been described, and tried in court. All that were present in the court room died of the jail fever in forty-eight hours,- judge, lawyers, constables, witnesses, prisoners, and spectators- in all over three hundred persons.

London had a great plague in which 100,000 persons died, and a greater number would have been taken had not the city been purified by a great fire. In rebuilding, more attention was paid to sanitary laws, which were just beginning to be known, and this prevented the recurrence of the plague.

However, it is not necessary to go back to the sixteenth century, even, to find very unsanitary conditions existing in England. In the fourth report of the medical officer of the Privy Council, dated 1861, these words are found in regard to one place, "In the great majority of cases, even in the center of the town, no accommodation of any kind is provided, and hence the adult male population defecate habitually in the gardens or in the roads." In another place it is stated that "Children's excrement, and other refuse, are frequently allowed to remain dotting the space before and behind the houses." In

the seventh report, dated 1864, is found the statement that at Seacroft, "It is the practice to throw everything in the shape of sewage, garbage, refuse, and even solid excrement, into the highway, on to the green, or the adjacent midden heaps, or into a ditch, if such be handy." In the ninth report it is stated that not until 1854 were houses under ten pounds rental provided with privies, or cess pools, the open street being used instead. In all these houses it was a common thing to throw all refuse and garbage into the court below. Liverpool's condition in 1844, is described in the "Health of Towns Report" of that year. Dr. Duncan in this states that the whole cellar population of Liverpool, amounting to more than 20,000 persons "Are absolutely without any place of deposit for their refuse matter." A like condition was said to exist in the front houses occupied by the working classes.

To sum up, the conditions in general were about as follows: The cities were overcrowded, this being due in Europe to the fortifications surrounding all the cities, the people either refusing to live outside them, or being compelled to live inside. The houses were low, dark, unventilated, and full of foul air, the floors being of earth and filthy. Cess pools were placed at convenient places, usually under the house, or in the courts. The business houses, or shops rather, were unhealthy, and were the means of spreading disease. The streets were narrow and dark, and, for the most part, unpaved. There were no sidewalks, and the people were compelled to walk thru the filth thrown into the streets during the night-time. There were no attempts made

to keep the streets clean. The surface of the streets was covered with solid filth, while the soil was saturated with the liquid, which contaminated both the sub-soil, and the public wells. The open water courses thru the towns, formerly used as sources of water supply, became so polluted that the stench arising from them filled the air, and the authorities in some cases arched them over, turning them into sewers of deposit.

The wells were located in the public squares, and because of the trouble in carrying the water to their dwellings, the people used it sparingly, never indulging in such luxury as a bath. Underwear was not changed because of the trouble and expense in washing. The poor quality of food caused much sickness. Because of the condition of the country roads, and the poor means of transportation, fresh supplies of food could not be obtained regularly. There were no markets, no slaughter houses, and no sanitary control of the food supply at all. Such were the unsanitary conditions one hundred years ago.

Many of the nations of ancient history practiced sanitation, and with their limited means and tools and knowledge, erected many great works which served the interests of public health. The ancient Hindus and Parsees were practical sanitarians, tho they have in a great measure forgotten the science. At that time the water and soil were holy, and the pollution of either was a punishable offense. The religion of the Parsees was Zoroastrianism, and one of the teachings of the founder, Zoroaster, was that flowing water courses should not be defiled. The remains of works of water supply and sewerage have been found in

all the important cities where excavations have been made, as Nineveh, Jerusalem, Carthage, and Rome, and in many of the smaller cities as well.

The Romans built gigantic aqueducts, canals, and works for the supply of water to their cities, both in the home country, and in their provinces. A great many of these ancient cities had sewerage systems, some of which are in such a good state of preservation that they are in use today. It is interesting to know that history records the use of tubular pipes by the Romans, Assyrians, and Babylonians. The Grecians had advanced ideas of sanitation, their homes having sanitary convenience, being clean and healthful. Besides this cleanliness in the home, in both Greece and Rome there were public baths, those of Rome, built during the time of the Emperors, being magnificent and costly structures, devoted to recreation, personal cleanliness, and health. Thus the people took great pride in personal cleanliness, and cleanliness of the home, and the authorities in most cases were public spirited enough to enact sanitary measures. Civilization kept pace with the good sanitary conditions, and the nations named were powerful, the people being refined and cultured.

Following the period came a dark era of decay and retrogression. During the Dark or Middle Ages, arts and science decayed, and with the decay of civilization, came a neglect of sanitation, until the knowledge of it was lost. History here shows that the sanitary condition was a true index of the degree of civilization of the nation. Personal cleanliness was

no longer considered a virtue, and the practice of bathing was given up almost entirely. The works for the supply of water were not kept in repair, and the sewerage system became clogged and useless. Dirty bodies and personal uncleanliness became a religious virtue, because the monks, with their ascetic practices and uncleanness, had a great influence upon the people, purposely keeping the masses in the deepest ignorance possible. Their examples of uncleanness were blindly followed by the masses. It was during this period that the noisome cess-pool came into existence, being first used at the monasteries, and then at the feudal castles. The cities soon presented the worst imaginable appearance, and plague and pestilence followed with terrible certainty. Sickness and the death rate increased rapidly, whole communities being decimated, and in some cases, even a much larger percentage of the people of the towns falling victim to their own filth. A terrible retribution followed this defiance of natural laws, in the form of the Black Death, which took 2,500,000 of people in Europe alone, or one person in four. This state of unsanitation continued until the conditions mentioned before existed.

At the commencement of the century just passed, a new era of sanitation began. Men began to study the conditions which caused the disease and rapid death rates of which many of them were then suffering and had suffered in the past. Men began to specialize, and to concentrate their energies upon this branch of engineering which deals with the public health. For the first fifty years there was a steady, though not very rapid de-

velopment, but it was only during the latter half of the century that sanitation made such rapid strides. Large and systematized efforts by the public for the improvement of the sanitary conditions of communities date only from the beginning of the second half of the nineteenth century. A new idea dominated the minds of those interested in sanitation, and a new principle came to be recognized. Before this time all works, such as water works, and sewers, were built rather from necessity, to fulfill the requirements of comfort and necessity, and to provide necessary commodities. Now, the health point of view was taken, and the public health was the recognized goal of sanitary engineering.

With this idea came the recognition of the fact that in order to maintain healthful conditions in a community, it was necessary to construct and maintain large and important sanitary works. It was also known that the best results could not be obtained without the assistance of individual householders, who must establish sanitation in the dwellings, stores, and places of work.

As a natural consequence of the recognition of the principles just stated, much attention was directed toward the securing of a public water supply, abundant and pure, to the extent that it would not produce disease. The idea of a public water supply began to grow when it was discovered that town wells were polluted from cess-pools, privies, and leaky sewers. Many of these wells were closed up, thus giving public water works a great impetus. After the art of casting iron pipes was discov-

ered, in 1809, there was a rapid increase in the number of cities having a public water supply. Before that time, hollow logs were sometimes used for water mains.

The following statistics will show the rapid growth in the number of public water works, especially in the last fifty years. Before the beginning of the nineteenth century, there were but five public water works in the United states, and prior to 1850, there were only 68 water works. In 1880, there were 630 water works systems in operation, 1,598 in 1888, 2,040 in ~~1900~~ 1890, and, according to the "Manual of American Water Works," there were 3,196 water works systems in existence in the United States in 1897. The growth was as rapid in Europe, practically all of the works originating since 1850.

Every city of any consequence in either Europe or the United States, now has a system of water works, more or less adequate. Paris, France, has one of the largest systems of any of the European cities. It is a double system of supply, river water being used for public purposes, while that for domestic uses is conveyed to the city thru large aqueducts from springs in the mountains. These works have been increased from time to time, the last addition being in 1894. The river Elbe supplies the city of Hamburg, Germany, and after the severe epidemic of cholera in 1892, caused by polluted water, large filter beds were built, and these have been in operation since 1893.

Vienna gets its supply of water from the pure springs up in the Alps, a distance of eighty or ninety miles. Naples completed a new water works system in 1885, as a result of a violent

cholera epidemic.

New York City probably has the most extensive system of water works of any of the American cities. Two large aqueducts convey many millions of gallons of water daily to the inhabitants of the city, and at Jerome Park, there is a large and extensive storage reservoir. A large dam is in process of construction now for the purpose of collecting the water from the Croton water shed as an additional supply to the city. Because of the contamination of supplies of water, many cities are finding it necessary to tap distant sources of supply, at great expense. In many cases it is impossible to secure a supply which is not polluted, and then it is necessary to construct works for the purification of the water, Albany, New York, and Philadelphia, Pennsylvania, have put in large sand filtration works for the purification of their water supply. Valuable researches have been made on the sand filtration of water in the last few years, at the Lawrence Experimental Station of the Massachusetts State Board of Health, also at Louisville, and Cincinnati, on mechanical filtration of water.

The development of sewerage works has been much slower than in works of public water supply. It has taken longer for the people to see the need of the sewerage work. Another reason is that tax payers are usually willing to pay a small annual tax for the water they use, and this insures the financial success of a water supply works. There is no revenue from a sewerage system, and in case the sewerage must be treated before being discharged into a body of water, or water course, there is a

large operating expense.

As has been stated, there were a few very crude sewerage-works in ancient times, but the construction of sewers by engineers dates from the beginning of the nineteenth century.

Those first constructed were intended for the removal of storm water only, the introduction of liquid household wastes and human excreta coming at a later time. As was true in regard to works of water supply, so there has been the greatest development in sewerage works since 1850. Prior to that time, few if any cities had a system built according to any general plan, tho many laid underground conduits, laid haphazard, improperly constructed, and not water tight. The real function of sewerage, and the benefits to be derived from an adequate sewerage system were not thoroughly appreciated until very recently. It was not until 1815 that faecal matter was allowed to be discharged into the sewers of London, and not until 1847 was it made compulsory. The man to first advocate the use of modern sewer pipe was Edwin Chadwick, an Englishman, in 1842.

The history of the progress of sewerage works in Europe must begin with the well designed system of Hamburg, Germany, introduced after the great fire there in 1842. A good system was constructed in Dantzic in 1869-71, and Berlin followed in 1870-80. The first modern main sewer was built in Paris in 1851, and a new system, which comprised several large intercepting sewers, was adopted in 1856. Naples, Italy, introduced a modern sewerage work immediately after the cholera epidemic in 1884. Modern sewers were laid in Rome in 1871, in addition to

the old system of drains. The construction of an adequate system of sewers, and the procuring of an outlet such that no ill effects will result from the pollution of the water of the river Thames, has been a very serious problem in London. Formerly the rivers emptied directly into the Thames, and because they were locked, or filled by the rising of the tide in them, they were filled with deposits, and many basements of buildings were flooded.

Between 1850 and 1875 the system which London has today was constructed. It consists of a series of high and low level intercepting sewers which carry the sewage by gravitation and by pumping to a point fourteen miles below London Bridge. Two reservoirs were built, in which to collect and hold the sewage until high tide, when it was discharged into the Thames River through two outlets. It soon became necessary, however, because of the pollution of the lower Thames, to purify the sewage in some way. Accordingly, a chemical treatment was first carried out, and recently a bacterial treatment has been used, which is much more successful than the chemical process.

In the United States, as in Europe, the great development in sewerage work has been since 1850. Mr. Julius W. Adams was appointed to draw up plans for the sewerage in Brooklyn in 1857. The sewerage system of Chicago was planned and designed in 1858, that of Providence, Rhode Island, in 1874, the final plan for the ultimate disposal of the sewage being completed in 1884. The main sewerage of Boston was planned in 1876-77, and constructed in 1878. Colonel Warring constructed the sanitary

sewerage system of Memphis in 1880, after the yellow fever epidemic of 1878. This was the first prominent use of the "separate system" of sewerage, and is an important epoch in the history of the development of sewerage works. Many engineers disagreed with Colonel Warring, there being many very spirited discussions, but it proved a success in Memphis, making that a healthful city. Many smaller cities and towns profited by this experience at Memphis, and constructed similar systems. Only a few of the principal cities have been mentioned, but within the last fifteen years almost every town with a population of five thousand has its sewerage system.

With this universal construction of sewerage works came the question of its disposal, and the sanitary engineer was confronted with the problem of the pollution of rivers, lakes, and bays, which were to serve as sources of water supply. Until within the last few years in both Europe and the United States the water courses were considered the natural receptacles of sewage, and the only consideration was how to get it there with the greatest convenience and the smallest expense. This led to the pollution of water courses, and as the population increased, the evil grew worse. It was quite generally thought at first that the rivers had the power of self-purification, but it soon became apparent that this purification was insufficient. The matter was first taken up systematically in England, a Royal Rivers' Pollution Company being appointed in 1868. This commission made several very long reports, clearly showing the

evils which were resulting from the pollution of rivers. The result was the passing of a "Rivers' Pollution Act," making it illegal to discharge crude sewerage into any water course, and providing for government boards, whose duty it was to preserve the purity of the streams.

France and Germany took up similar measures soon after. The matter was first taken up in the United States in Massachusetts where the rivers are polluted by both city sewage and manufacturing wastes. The most valuable information has been given out by the Massachusetts State Board of Health, and the Rivers' Pollution Committee of the American Public Health Association.

The question of sewage purification naturally followed the enactment of laws against river pollution. The problem was first taken up from the standpoint of utilization of the sewage, either in an agricultural way, by land irrigation, or by treating it with chemicals. Engineers then thought that it would be possible not only to purify the sewage, but to realize a profit from the product. It was soon found that this is not possible.

The large cities of the United States and Europe have different plans for the disposal of sewage, according to their location and natural advantages. New York, London, Boston, San Francisco, and other cities on the coast, discharge their sewage into the sea. In Manchester, England, a scheme was proposed, consisting of an underground conduit fifteen and a half miles long, thru which the sewage flows to an estuary of the Mersey River. Chicago has constructed an immense drainage canal, into

which the sewage of the city is discharged, thence down the Illinois River to the Mississippi. This was constructed at a cost of many millions, the object being to preserve the purity of the water supply derived from Lake Michigan. In Europe several large cities have established sewage farms, the sewage being purified by irrigation on land. This process is called broad irrigation, and requires a porous soil, low rainfall, and a cheap land. Paris, Berlin, Dantzic, and many smaller cities, report this method as satisfactory. This method has proved a success in some of our western states, where there is a low summer rainfall and sandy soil.

Professor A. N. Talbot, of the University of Illinois, in a paper which he read at a meeting of the Western Society of Engineers, December 5, 1900, discusses the recent progress in sewage purification. Dilution, or discharge into streams, or bodies of water, and broad irrigation have been mentioned above.

Another process discussed is chemical precipitation. The chemical precipitation works at Worcester, Massachusetts, are the most successfully operated works in the world, caring for a daily flow of seventeen million gallons of sewage. In general, this method has been found expensive and inefficient, so much so that it is being abandoned in both the United States and Europe.

A fourth process discussed was intermittent, downward filtration. The sewage is passed on to porous beds of sand and gravel, or some porous material, in layers. The principle of such beds is well stated by Professor Talbot, as implying the gradual sinking of the sewage into the bed, not saturating the

bed (filling the voids), but spreading out in thin films over the surface of the grains and being held by capillary action throughout the bed, so that each layer of liquid is pushed downward by the next application of sewage, until finally, after several doses have been applied at the surface, the first of the effluent is forced out into the under drains. When the sewage can be properly distributed over the beds, this is a very efficient process of sewage purification.

Another method is by passing the sewage through coarse bacteria beds, beds consisting of tanks filled with coarse fragments of stone, clinkers, coke, burnt clay, or other durable material. These beds rely upon the action of the bacteria which develop around the material composing the bed, for their efficiency. The beds are filled with sewage from which the coarser particles have already been screened out, and this is allowed to remain for two, three, or four hours, and then slowly discharged. This process presents many difficulties, and is not widely used at the present time.

Contact beds are similar to the coarse bacteria beds, the material in the former being finer than that in the latter. Professor Talbot states that a single contact removes 60% to 65% of the settled sewage from the septic effluent, and the second contact removes 50% to 60% of the remaining organic matter, making an efficiency of 90% to 95% for the whole process.

Perhaps the best method of sewage purification is by the use of the septic tank. Professor Talbot defines the septic tank as being, "A large tank, covered so as to exclude light and air,

wholly or substantially, or if open, arranged so that the floating mat which forms on the surface will accomplish the same object, through which the sewage flows in such a way that it has a very regular current, and a velocity so slow that the matters in suspension in the sewage rise or fall, by reason of difference in specific gravity, and are retained in the tank, where the organic matter will be decomposed, while the effluent will flow out at the lower end of the tank." The operation of the septic tank has been very successful, and this process has been adopted by a good many cities, both large and small, in Europe and the United States. Champaign has a septic tank, which has worked very successfully, but its capacity is now insufficient to allow the sewage to remain in the tank a proper length of time. An efficiency equal to the chemical precipitation has been reached, and at slight expense.

It is thus seen that great progress has been made in the scientific treatment of sewage, many processes being developed and experimented with. There are many difficulties involved in the problem, and no solution to which all will agree has yet been discovered.

It is only within the last few years that the paving of city streets and the maintenace of cleanliness on the same, has been considered the work of the sanitary engineer. In both the United States and Europe there has been great progress in the cities in the matter of laying pavements with durable foundations and water tight surfaces.

The development of systematic street cleaning has been much more rapid in Europe than in the United States. There the larger cities have endeavored for several years, to keep their principal streets in a sanitary condition, by cleaning the surface, the gutter, and the sewer catch basins. The greatest impetus to street cleaning in the United States has been given by Colonel George E. Waring, who was elected to the position of commissioner of street cleaning of the City of New York in 1894, taking charge of the work January 15, 1895. The conditions of the streets before that time are well described by Colonel Waring in his book, "Street Cleaning and its Effects." He gives the following description: "Before 1895 the streets were almost universally in a bad state. In wet weather they were covered with slime, and in dry weather the air was filled with dust. Artificial sprinkling in summer converted dust into mud, and the drying winds changed the mud to powder. Rubbish of all kinds, garbage, and ashes lay neglected in the streets, and in hot weather the city stank with the emanations of putrefying organic matter. It was not always possible to see the pavement, because of the dirt that covered it. One expert, a former contractor of street cleaning, told me that West Broadway could not be cleaned because it was so coated with grease from wagon axles; it was really coated with slimy mud. The sewer inlets were clogged with refuse. Dirty paper was prevalent everywhere, and black rottenness was seen and smelled on every hand."

That even worse conditions than described above prevailed, is shown by the photographs of these streets taken at this time,

and by the affidavits of a committee of the City Club, this club being organized with a view to securing the removal of Commissioner Brennan for neglect of duty.

Colonel Waring reorganized the department, retaining only the competent men then on the working force, and within a few months the streets presented a very different appearance. A standard in street cleaning was set by him which is being followed by many cities of the country.

The removal and disposal of garbage and any solid refuse which may collect must form a part of the sanitary system of a city, if it is well arranged. It was formerly thought that each inhabitant should dispose of the garbage and refuse which came from his home. Later it was accomplished by contract, the matter being carried away to some dumping ground, or thrown into the sea or water courses.

Within the last fifteen years it has come to be recognized as being intimately connected with town sanitation, that it belongs to the province of the municipal and sanitary engineer, and that it is one of the most important problems with which it has to deal. Much progress has been made because of the systematic efforts of engineers in Europe and later in the United States.

The solution of the problem is now sought in two ways, viz., by the burning of the refuse matter in furnaces specially constructed for this purpose, and by its reduction by steam heat, the object being to manufacture grease and powdered manure, from

which a revenue is realized. All the methods that have been attempted have been found objectionable, and there is a great field here for the sanitary engineer.

The matter of a provision of healthful food supplies and a proper and efficient food inspection is in the province of the sanitary engineer. At the beginning of this century almost all the markets were open, but now these are in a large measure replaced by large covered structures. In the past thirty-five years many of the larger cities of Europe, and a few of the cities of the United States, have erected large markets, where the sale of food takes place. These markets have many advantages over the old system, chief of which are the protection which they offer to the market people and the public from the weather, the fact that the food is not damaged by rain, snow, heat, or dust, that fresh market products are obtainable every day, and that the provisions are easily inspected. These markets must have good connection with railroads, harbor-docks, rivers and canals, thus offering sanitary and engineering problems. The sanitation of bakeries has recently been brought under the supervision of the health boards.

Closely connected with the public markets are the municipal slaughter houses which do away with the nuisance of private slaughtering, and make it possible to make an easier and more thorough inspection of the meat. In the last part of the century just passed, almost all large cities in Europe and the United States have constructed these slaughter houses or centralized abattoirs, and located them at considerable distances from the

crowded districts of the cities.

Within the last fifty years another municipal problem has arisen, especially in Europe, that of enlargement and reconstruction of their system of streets. As has been stated before, most of the cities of Europe were surrounded by fortification walls, but it has become necessary because of the growth of these cities, to tear these walls and fortifications down, and extend the limits of the cities. Between 1850 and 1870 many changes were made in the streets of Paris, grand avenues, boulevards, and wide streets were laid out, with rows of shade trees and parks lining either side. Other cities of France were changed in a similar manner, but on a smaller scale.

The development in this problem of the sanitary engineer has been even more rapid in Germany. Wide, straight avenues lined with modern dwellings and stores have taken the places of the dark, narrow, and crooked streets, with old dwellings and warehouses; new suburbs have been laid out, provided with water and sewerage facilities and beautified by parks and gardens. The changes wrought in many German cities within a very few years have been remarkable.

This is not such an important problem in this country, because our cities are much newer. After the great Baltimore fire, however, the old street lines were changed, the new streets being wider than the old. Within the next fifty years there will be a large amount of this work done, as many of our cities will need to be enlarged and embellished.

Great progress has been made in the provision of decent and sanitary houses for the poorer population in the crowded districts of larger cities. In cities more than a hundred years old this is a very important question. The matter was first taken up in England in 1842, when Sir Edwin Chadwick made his report "On the Conditions of the Laboring Population." Interest was first aroused in the United States in 1856, when the state of New York appointed a committee to inquire into the condition of the tenements. The items of the report of this committee, handed in the following year, were startling to the public, and the tenement house question has ever since been under control of municipal authorities. Since then this question has been treated on a large scale in both Europe and the United States. The large Peabody workingmen's building, and the improved industrial dwellings of Sir Sidney Waterloo are the result of this interest in London. The Riverside apartments and other model tenements solve the problem in Brooklyn, but the solution has not yet been reached in New York City, because of the many peculiar difficulties there. Many suggested improvements have come from citizens' associations, and legislative tenement house commissions, also from the "Model Tenement House Competition," organized by the Engineering Record, then known as The Sanitary Engineer. Real progress began with the passing of the Tenement House Act, in May, 1879, which limited the space of the lot to be built upon, and also required that all bedrooms have windows for direct admission of light and air.

This Act also gave increased power to the board of health, which brought about important results. The labors of the Tenement House Commission appointed in 1894 have been productive of great results. Much progress upon the tenement house question has been made in Chicago and the other large cities of our country, but there are still many improvements to be made.

There has been much improvement, in the last fifty years, in the sanitary features of dwelling houses. The details of drainage, water supply, ventilation, lighting and general sanitation, are now carried out by sanitary engineers. That great progress has been made is shown by the improvement in the water closet, and the improved methods in plumbing and ventilating. At the middle of the century, the pan closet, with all its evils, was used almost universally. The vent pipe has come into use, and now the fundamental principal of house drainage and sanitation are well established.

Improvements in sanitation have not been confined to private dwellings, but have also extended to public buildings, such as schools, hospitals, jails, and military barracks.

The improvement in the construction and equipment of school buildings has been marked. They are now well heated, thoroughly ventilated, and are provided with decent and inoffensive sanitary conveniences. Personal cleanliness is encouraged by the establishment of free school baths, and the pupils are made to feel that a clean healthy body is an essential to a healthy, vigorous mind.

Much attention has been given to the improvement of hospitals. In the old or block plan, the wards were crowded, insufficiently ventilated, and built one above the other. The pavilion system, where possible, has replaced the old system, and now our hospitals are spread out over larger areas. In many cities the hospitals are being built out in the suburbs, where there is more room, but because of extremely high price of land, cities like New York and Chicago are compelled to follow the old plan.

The fatal jail fever in England has been mentioned, and while conditions were never as bad in this country, it is only within the last few years that proper sanitary conditions have been brought about. Formerly cells were located in the dark cellars of monasteries, convents, towers and castles, or court houses, and epidemics were frequent. In both Europe and the United States the jails and prisons are provided with good sanitary conveniences, are well heated, and have plenty of fresh air and light.

The modern military barracks differ very much from the old style barracks erected in the fortified towns of Europe. The barracks now consist of well ventilated, well lighted buildings, provided with all the modern conveniences of light and heat. There has been much improvement, too, in the laying out of military camps. The soldiers not many years ago, had good reason to dread the camp worse than the battle field. In the Spanish American War, although many of the camps were poorly located, and the conditions were far from ideal, much precaution was taken

for the comfort and health of the troops. Lumber was provided for tent floors, the human excreta was carted away in tubs, the water supply was that of the city near which the camp was located, and in some cases each company was provided with a filter.

Another improvement in sanitation is the providing of public baths, public laundries, places of public comfort by municipalities, both in Europe and the United States. Practically all of the large cities of Europe have them, and in many cases the smaller cities too. Birmingham, England, has six complete sets of public baths, and an open air swimming pool. These are well managed, and are among the best in England. Liverpool has some very efficient baths, both salt water and fresh water. The city has also erected stand-pipes, by means of which every house can be supplied with salt water. In London about $3,000,000 is invested in public baths and laundry establishments. In this city alone there are over twenty-five public baths. Other cities in Europe which have adequate public baths are Edinburgh, Glasgow, Berlin, Hamburg, etc.

In the United States such cities as New York, Buffalo, Chicago, Boston, Philadelphia, Pittsburg, Baltimore, and many other cities, even down to a population of 10,000, have public baths. The erection of public baths in one of the smaller towns in Missouri was prevented by one of the older citizens, who made the statement before the city council, which was at that time discussing the question, that he had not taken a bath in sixty years, and had not been sick a day during that time. This spirit

is the exception, however, and the next few years will see the erection of public baths in almost all our cities of ten thousand and above.

The public laundries, or wash houses, were usually built in connection with the bath, though they sometimes occupied separate buildings. These wash houses are fitted with tubs, pails, washing boards, hot water, cold water and steam, steam wringers, and drying horses. It is the purpose to discourage the professional wash woman, an extremely small fee being charged, and to aid the poorer classes.

It has been the custom in England for a good many years, to provide places of public comfort. London is well supplied with them, for both men and women. Underground conveniences are now usually built, the entrance being in the center of the street. Birmingham, Liverpool, and other cities in England, have a splendid system of latrines, urinal and water closets. In Germany, Berlin, Altona, Brunswick, Dresden, Hamburg, Leipzig, Munich, etc., are supplied with similar accommodations, and important improvement being the erection of chalets for ladies, with the notion store in front. Some of these stations are free, and at others a very small fee is charged.

The United States in backward in this matter, very few cities having places for public comfort. For the information in regard to public comfort stations, baths and laundries, I am indebted to the report of "The Mayor's Committee on Public Baths and Public Comfort Stations" of New York, in 1897.

In large cities, like New York, Chicago, and Pittsburg, the great quantity of black smoke is not only a nuisance, but very injurious to delicate lungs, and the great quantities of carbon dioxide and sulphuric acid is injurious to the health in general. Great improvement has been effected in the last few years by the use of hard coal, the better firing of boilers, the use of smoke consuming appliances in the boilers, and when possible, the removal of large manufacturing industries away from the crowded districts.

The work done by State Boards of Health since 1870-80 has been important, thorough, far reaching, and of much practical benefit. The interest which finally culminated in the organization of the first State Board of Health, the Massachusetts Board in 1869, began in 1849, when the State Legislature passed an act appointing three commissioners to prepare for a sanitary survey of the state. The first report was issued in 1870, and since then these reports have been of great value to sanitarians and sanitary engineers. The work of this board has been devoted largely to the purification of water supplies, the disposal of sewage, and the effect upon the health of the people.

The scope of the work of the Massachusetts State Board of Health can be seen by noticing briefly the report for 1902. It gives first a general report of the health of the state, with a condensed account of the work done under the laws defining the duties of the Board.

The second division is, "Advice to Cities and Towns." The Board is required to consult with and advise the authorities of

cities and towns, who are establishing or are about to establish systems of water supply, sewerage or drainage. The Board makes a study of conditions at the expense of the state, and gives the authorities the benefit of their expert advice. It also consults with persons engaged in or about to engage in manufacturing or other business whose sewage is likely to pollute any inland water. During the year the sources of water supply of forty-six cities were examined, and advice given; the authorities of fourteen towns were advised in regard to their sewerage systems and the disposal of sewage; twelve applications for advice were made and given relative to the pollution of ponds, streams, and other bodies of water.

The third division relates to the examination of water supplies begun June 1, 1887. Chemical, and in most cases, microscopic analyses were made of the water from over two hundred and fifty sources of supply within the state.

A fourth division is a report of the experiments upon the purification of sewage and water at the Lawrence Experiment Station. These experiments were continued throughout the year, and many valuable results obtained.

Next is a report upon the bacterial tests made by the Board. The extent of this work can be best given by quoting from the report of 1902, page 245.

"During the past eight years the work at the experiment station along this line has covered a wide field, and has included examinations of over 18,000 samples, including 4,700 samples of polluted river water, 9,100 samples of filtered water,

2,200 samples of other potable waters, including samples from springs, curb wells, tubular wells, domestic wells, ponds, and other surface supplies, etc., and 2,100 miscellaneous samples, including shell fish, sea water, ice, milk, dust, excrement from men and animals, grains, food stuffs, etc. Investigations have also been made upon the reasonable distribution of B. coli, the elimination of B. coli from water by storage, as in reservoirs, and studies upon the similarity between the length of life of B. coli and B. typhosus under a variety of conditions."

A report upon the examinations of the outlets of sewers and the effect of sewage disposal follows, to which 166 pages are devoted. Two classes of outlets were examined, those which discharge into the sea, or into tidal harbors, or into estuaries along the sea coast, and those which discharge into rivers and other inland waters.

The next subject considered is the food and drug inspection, with the report of the analyst. The remainder of the report is devoted to the discussion of the distribution and use of the Diptheria Antitoxin, of the Bacilli of Tuberculosis, and of Typhoid Fever, with statistical summaries of disease and mortality.

The Michigan State Board of Health was created in 1873. This board has devoted its attention to the causes and means of restricting and preventing such diseases as typhoid fever, consumption, pneumonia, diphtheria, scarlet fever, measles, whooping-cough, and small-pox, rather than to water supply and to sewage purification. The results of the work of this board

are important. A splendid system of local boards of health are now established by law, with efficient health officials. These local boards report to the state board, which issues bulletins to be sent to all the local boards, each local board thus getting the benefits of the experience of all the others. The following charts are taken from these bulletins;

DEATHS IN MICHIGAN
1884-93.

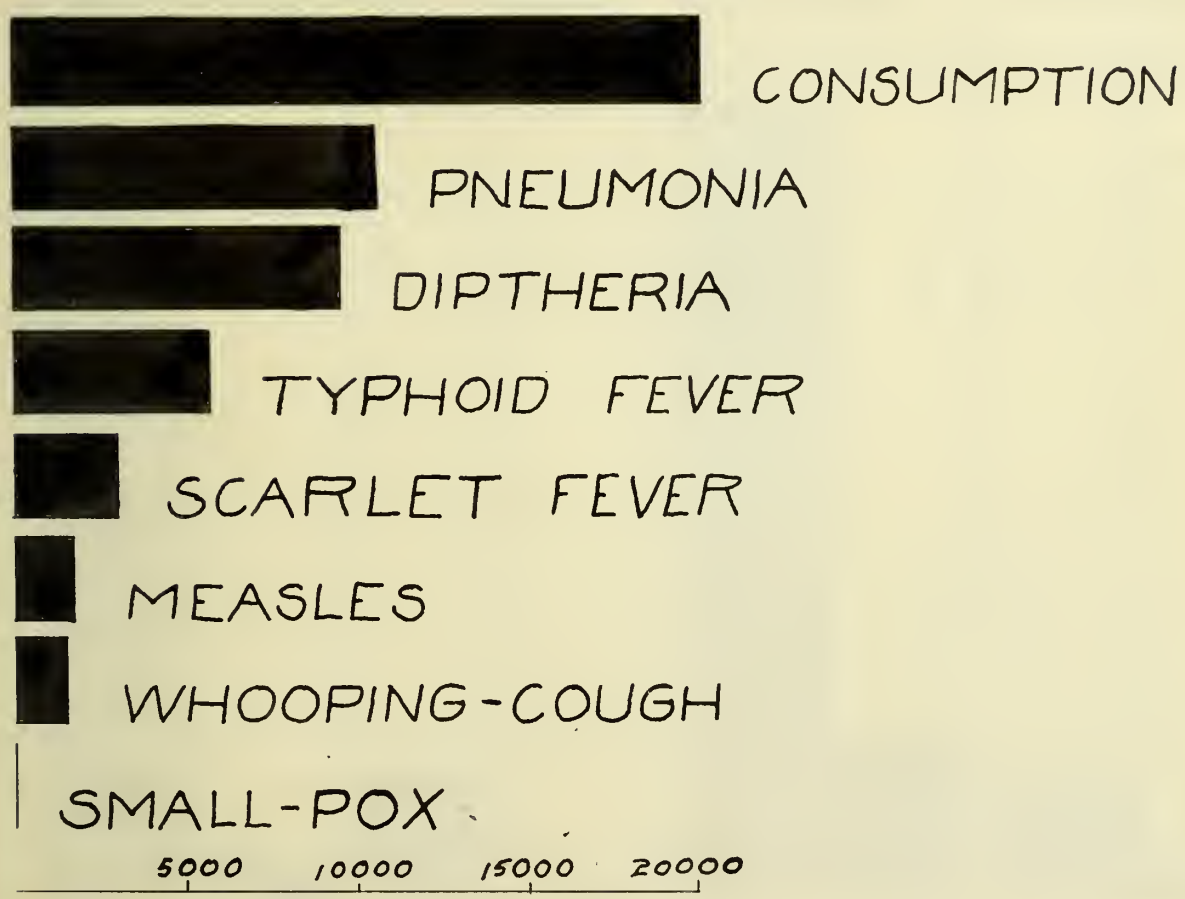
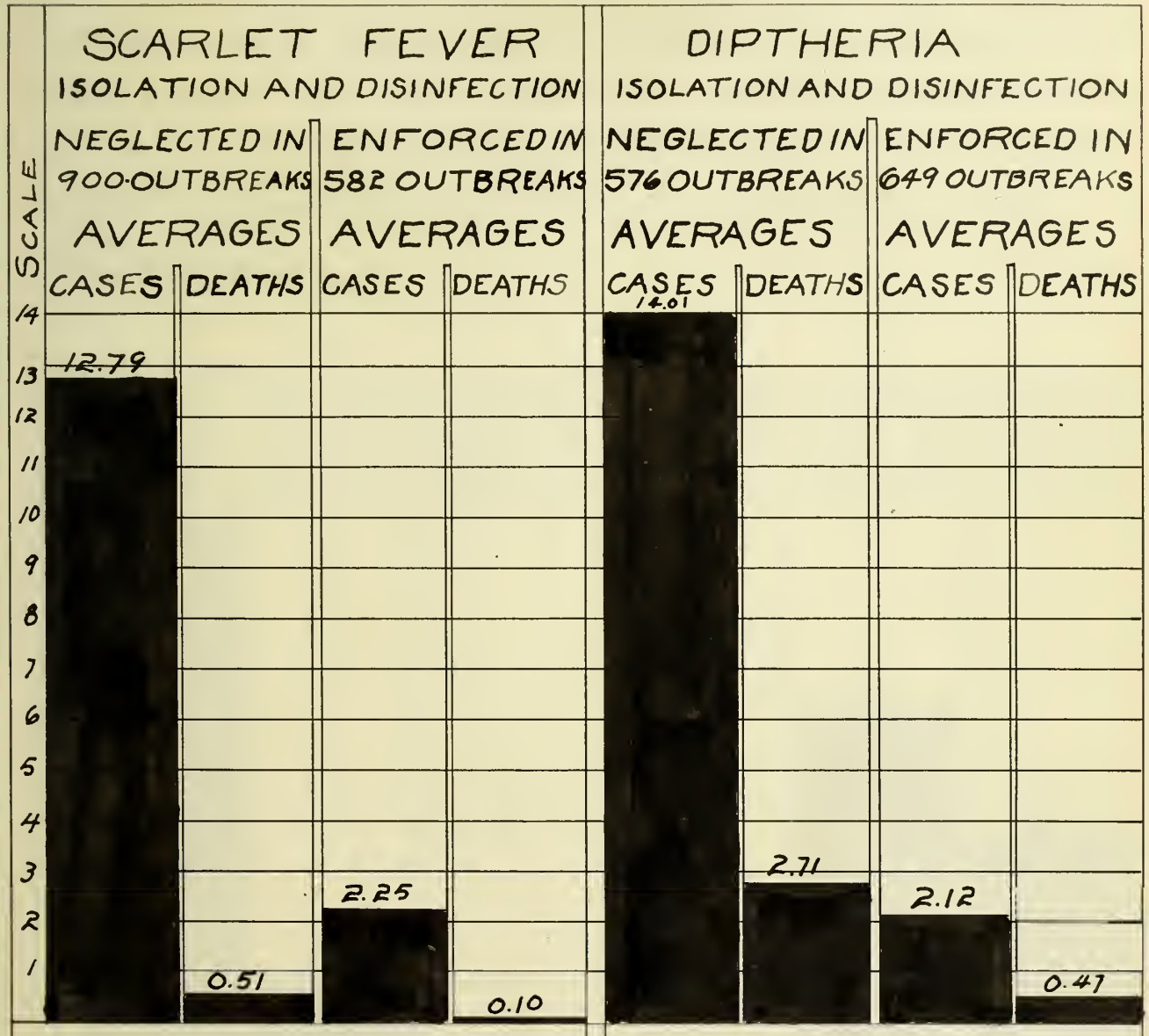


DIAGRAM DRAWN TO SCALE SHOWING RELATIVE IMPORTANCE OF ABOVE DISEASES.

ISOLATION AND DISINFECTION RESTRICTED SCARLET FEVER AND DIPTHERIA IN MICHIGAN DURING THE 10 YEARS 1887-'96

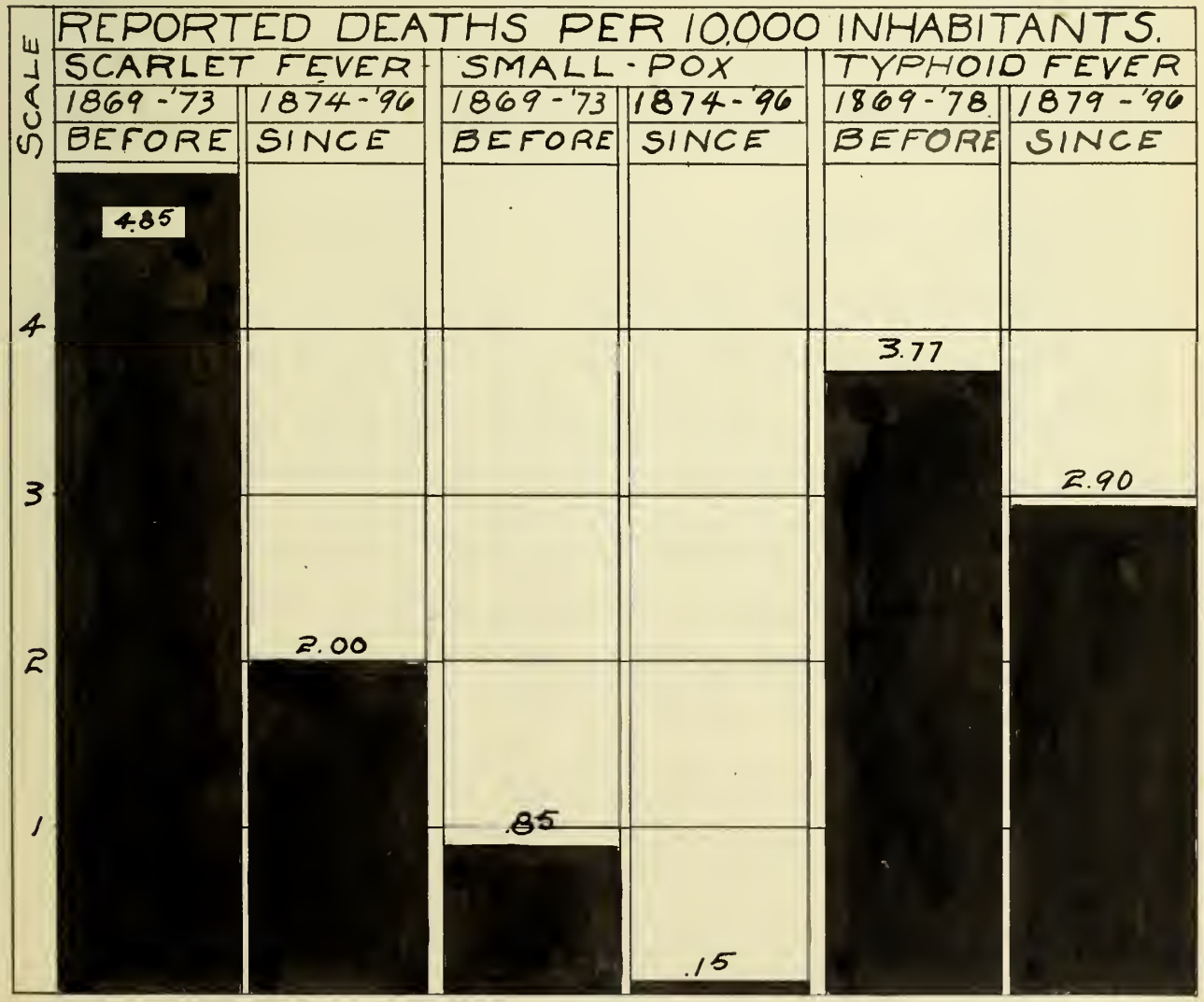


TOTALS: OUTBREAKS 5030, CASES 33785, DEATHS 1,619.
INDICATED SAVING OF CASES
(5030 x 12.79) - 33785 = 30,549.
INDICATED SAVING OF LIVES
(5030 x .51) - 1619 = 946

TOTALS: OUTBREAKS 4,330, CASES 25,146, DEATHS 5,312.
INDICATED SAVING OF CASES
(4,330 x 13.01) - 25,146 = 31,107.
INDICATED SAVING OF LIVES
(4330 x 2.71) - 5312 = 6422.

LIVES SAVED BY PUBLIC-HEALTH WORK.

COMPARISON OF DEATH-RATES IN MICHIGAN FROM SCARLET FEVER AND SMALL-POX BEFORE AND SINCE THE STATE BOARD OF HEALTH WAS ESTABLISHED, AND FROM TYPHOID FEVER BEFORE AND SINCE ITS RESTRICTION WAS UNDERTAKEN BY THE STATE BOARD. (COMPILED FROM THE STATE DEPARTMENT'S "VITAL STATISTICS" OF MICHIGAN.)



The two state board mentioned were the first established, and New York followed in May, 1880. Very few states in the Union are now without this useful institution.

The first city board of health was created in New York City in 1866, and now nearly every city and town has its board of health, whose labors are devoted to town sanitation. These boards are practical and efficient, and much good is being done by them. They prepare and publish vital statistics and sanitary maps, profiles and diagrams showing the relation between the location of old water courses and the mortality of districts near by, and those farther away, and diagrams showing the relation which sewerage, density of population, meteorological conditions, etc., bear upon mortality.

In 1855, during the Crimean War, a sanitary commission was appointed in England, which did valuable service. Valuable results were also accomplished by a similar commission in our own country, the United States Sanitary Commission of 1861.

Another step in the direction of sanitation is the introduction of sanitary science into the universities of Germany and the United States. A large number of the larger universities, and technical colleges, now have special courses in sanitary engineering.

Dr. George Reid in his book on Practical Sanitation discusses three measures for the prevention of the spread of infectious diseases, isolation, quarantine, and disinfection, which he calls "General preventative measures." He says, "It is only by the immediate isolation of early cases that one can hope to prevent an extension of infectious disease, and money is certainly well spent in providing the means of doing this, for not only is disease thus curtailed, and life saved, for economy is exercised, for illness means poverty, and poverty increases the rates."

A step in the right direction was made in England when the sanitarians secured the passage of the Isolation Hospital Act, 1893, empowering County Councils to form joint hospital districts and to contribute toward the cost of providing and maintaining hospitals.

It is often necessary in addition to isolation to establish a period of quarantine, and great progress has been made in this matter in the last few years. In many towns quarantine stations are provided by the authorities, and the occupants of infected houses are boarded and lodged free of charge until the disease is passed the stage of being communicated. People coming into the United States from the West Indies, or other tropical climates are compelled by law to go through a period of quarantine. The question of closure of schools, and prohibiting all public gatherings is now left largely to sanitary authority, under the advice of the Medical Officers of Health.

The importance of disinfection has come to be recognized, and many processes of disinfection are now in use. Dr. Reid, who is quoted above, gives the following: "(1) heat (dry or moist); (2) chemical substances (in liquid or powder); (3) fumigation (by gases or vapors); and last, but by no means least, (4) fresh air, and general cleanliness."

The work of the scientific and literary press has also done much to spread the knowledge of sanitary principles, and deserves mention in this connection.

A great deal has been done to better the conditions in our cities by the framing of building laws and ordinances by the municipalities. These laws regulate not only safe construction and protection from fire, but also healthful building construction, and healthful modes of living. Laws are now enforced regulating the width of streets, the height of the houses, the size and height of rooms, the number of windows and their position, the details of heating and ventilating, of surface drainage, of plumbing and sewerage, and of avoidance of defective gas piping.

What has been the effect upon the health and death rate of the people of this development in sanitation? Have the people received any benefits from the discoveries of sanitation? Are the discoveries of these numerous boards of health based upon scientific research, and are the laws enacted through their advice just and beneficial, or are they a detriment to the public health? Dr. F. L. Dibble, in his book, "Vagaries of Sanitary Science," answers the above questions in a way which is startling

to say the least. He ridicules the work of all sanitarians, state boards of health, commissions, and all other seeking the public health, except those in the medical profession. In the introduction he refers to a previous attack upon the reports of a local board of health, which brought upon him only biting taunt, and inmuendo. He makes the claim that sanitary science had its origin in a kind of disorderly agitation that suddenly seized the people of Great Britain, following an inquiry into the condition and manners of living of the poorer classes in that country. He further says that sanitary reform was not consequent to any new biological or pathological discovery, nor was it connected with any line of scientific research.

His position can best be shown by a few quotations from his book mentioned above. He says, "The author's amazement had no bounds when, on examining, one after another, the 'Settled Principles of Sanitary Science,' he found that these had no scientific basis; that they rested on froth, noise, and panic, and that the shapeless specters which the reformers had raised to intimidate the public disappeared when they were looked squarely in the face." He speaks of the germ theory of disease as being "whimsical, without any foundation in scientific inquiry, and not having the sanction of thoughtful and practical men in the medical profession." He calls the theory that want of cleanliness causes disease an "amiable delusion."

In regard to water analyses, he says, "We are forced to the conclusion that there are no better tests for drinking water than our first parents possessed; and that the instincts, taste,

and experience of a committee of farmers, mechanics, or intelligent housewives are more to be depended on in the selection of a public water supply than are the so called scientific tests of the sanitarians." In fact, he disputes the statements of sanitarians upon every subject investigated by them, the evils of polluted water, cess-pools, foul air and sewer gas, the causes of epidemics, etc.

This book was published in 1893, and though many of the statements of Dr. Dibble are true, later research has shown that most of them are wrong. Statistics gathered in different countries give proof of the marked beneficial effect upon the public health of municipal sanitary measures, such as water-supply, drainage, sewerage, street cleaning, garbage removal, etc. Some epidemics which formerly appeared ar regular intervals, have disappeared almost entirely, and many cities that formerly suffered are now entirely free from disease which was formerly common. This decrease in disease and the death rate of cities, as shown by annual statistics, form the best evidence of the good influence of sanitation. I quote from the paper of William Paul Gerhard, consulting engineer for sanitary works, read at a meeting of the Brooklyn Engineers' Club, February 9, 1899. "Take the case of London: at different periods of history the death rates were as follows: from 1660-79, the annual death rate was 80 per 1,000; 1681-90, 43; 1746-55, 35.5; 1846-55, 24.9; and in 1871, the rate had come down to 22.6 per 1,000."

"In Croydon, near London, the rate was as follows: 1848-55, 24.03 per 1,000; 1855-75, 19.56; 1876- 80, 17.07."

"In Brussels, the death rate in 1876 was 25 per 1,000, and in 1894, 18.1."

"In Vienna, the death rate was: 1848-57, 42 per 1,000; 1878-88, 28.6; 1893, 24.3; 1894, 22.8."

"In Buda-Pesth, the figures were as follows: 1876, 41 per 1,000; 1892, 27.9; 1895, 24.4."

"In Milan, Italy, the rate was 30 per 1,000 for 1880, and was reduced to 21 in 1894."

"In Copenhagen, the rate in 1884 was 24 per 1,000, and in 1894, 18.7."

In Stockholm, Sweden, the figures were: 1877, 23.7 per 1,000; 1884, 24.6; 1894, 18.3."

"German cities present even more striking examples of the benefits derived from sanitation. In Hamburg, for instance, in the period from 1838-44, before the sewerage system was introduced, the rate was 42.4 per 1,000. In the period from 1845-53, during the construction of the sewer system, the rate of mortality was 39.5; 1854-61, (the first eight years after the sewer system had been put in operation), 29.9; 1862-69, 22; 1871-80, 13.3."

"In Dantzic the rate was as follows: 1863-68 (before sewerage), 38.4 per 1,000; 1869-71 (during construction), 34.6; 1872-80 (when sewer system was completed, the rate fell to 28.8."

"Regarding deaths from typhoid fever, the following figures are instructive. The mortality in Munich from typhoid fever, was, prior to 1859, 24.2 per 10,000 deaths; 1860-65,

when there was no sewerage, 16.8; 1866-73, when there was partial sewerage, 13.3; 1875-80, after sewerage system was completed, 8.7."

"In Frankfort-on-Main the typhoid mortality was 8.7 from 1854-59, when there was no sewerage, and in the period from 1875-87, after sewerage was completed, the rate of mortality fell to 2.4 per 10,000."

He gives a very few examples in the United States. "In St. Louis the annual death rate in 1860 per 1,000 was 32, and in 1865-70 it became reduced to 20."

"The city of Memphis formerly had a death rate reaching as high as 109 per 1,000, and in the year 1897 its rate had been reduced to 23.56."

The effect of sanitation upon typhoid mortality is further shown by the typhoid fever statistics of the principal cities of the United States and Europe, compiled from the official reports of health departments, January, 1897, by John W. Hill, consulting engineer, Member American Society of Civil Engineers, Member American Water Works Association, and Member American Public Health Association. The death rate given is per 100,000 of population living.

TYPHOID FEVER STATISTICS

CITY	SOURCE OF SUPPLY	1890		1891		1892		1893		1894		1895		1896	
		POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE
LONDON ENGLAND	KENT WELLS & FILTERED WATER THAMES & LEA R.	4,180,654	16	4,222,157	15	4264076	11	4306411	16	4349166	15	4392346	14	4421955	14
LIVERPOOL	LAKE VYRNWY	513,493	24	517,116	25	513,790	25	510,514	53	507,230	58	503,967	37	632,512	32
EDINBURGH, SCOTLAND	IM'P WATER, PENTLAND HILLS	271,135	19	261,970	18	264,787	13	267,261	14	270,588	15	273,535	20	276,514	16
PARIS, FRANCE	OURCQ CANAL, WELLS, SPRINGS SEINE, MARNE & VANNE RIVERS	2,260,945	30	2,424,705	20	2,424,705	28	2,424,705	25	2,424,705	29	2,424,705	11	2,511,629	11
ST. PETERS-BURG	FILTERED WATER NEVA RIVER	842,000	57	. . .	..	. . .	..	954,400	51	954,400	49	954,400	87	954400	142
BERLIN	FILTERED WATER LAKE TEGEL, & RIVER SPREE	1,548,279	9	1,601,327	10	1,666,237	8	1,714,938	9	1,701,643	4	1,734,492	5	1,695,313	5
ROME ITALY	AQUA FELICE & PAOLI, FONTANADI TREVI.	417,392	35	427,684	36	438,123	26	449,430	34	456,777	30	465,563	63	473,296	27
CAIRO	NILE RIVER	374,838	260	374,838	235	374,838	163	374.838	154	374,838	135	374,838	90	374,838	141
SYDNEY AUSTRA'L.	IMP. WATER NEPEAN RIVER.	. . .	..	. . .	..	406,480	20	411,710	19	421,030	29	423,600	20	. . .	..

TYPHOID FEVER STATISTICS

CITY	SOURCE OF SUPPLY	1890		1891		1892		1893		1894		1895		1896	
		POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE	POP.	DEATH RATE
N.Y. CITY	IM'P WATER-CROTN and BRONX RIVERS	1,705,980	21	1,765,645	22	1,827,396	22	1,891,306	20	1,957,452	17	1,879,195	17	1,934,077	16
CHICAGO	LAKE MICHIGAN	1,208,664	83	1,250,000	160	1,438,010	104	1,600,000	42	1,567,727	31	1,600,000	32	1,619,226	46
PHIL: PA.	SCHUYLKILL DEL. R	1,046,964	64	1,069,264	64	1,092,168	40	1,115,562	41	1,146,000	32	1,163,864	40	1,188,793	34
ST. LOUIS	MISS. RIVER	450,000	34	452,000	30	460,000	37	500,000	103	540,000	31	560,000	19	570,000	19
BOSTON	LAKE COCHITUATE and SUDBURY RIVER	431,245	43	461,093	33	474,063	29	487,397	30	501,107	28	496,920	33	508,694	32
SAN FRAN-CISCO	IM'P WATER MOUNTAIN ST.	300,000	59	330,000	41	330,000	34	330,000	32	330,000	35	330,000	37	330,000	31
CIN. O.	OHIO RIVER	296,000	67	300,000	62	305,000	40	310,403	43	336,000	50	336,000	36	341,000	48
CLEVELAND.	LAKE ERIE	277,488	66	299,475	52	309,243	54	322,932	47	325,000	27	325,000	36	330,219	43
W'H'N-D.C.	POTOMAC RIVER	250,000	83	250,000	83	260,000	70	285,000	66	270,514	71	271,000	74	278,150	51
DETROIT	DETROIT-RIVER	230,000	18	230,000	13	230,000	51	230,000	61	250,000	26	280,000	22	279,000	20
INDIAN-APOLIS	DRIVEN WELLS and FILTER GALLERY	....	..	120,000	36	125,000	52	125,000	106	125,000	55	125,000	97	165,000	41
LOWELL MASS.	MERRIMAC RIVER DRIVEN WELLS	77,696	158	80,400	98	83,200	90	87,191	61	90,613	55	84,367	39	85,700	42
DAYTON-O	DRIVEN WELLS	60,000	20	60,000	32	63,000	44	75,000	64	85,000	20	80,000	47	85,000	25
QUINCY ILL.	MECHANICAL FILTER, MISS R.	31,500	83	34,000	32	36,000	50	37,500	48	39,000	77	40,500	59	42,000	26
TORONTO	LAKE ONTARIO	167,439	93	181,220	94	184,000	43	188,333	42	196,666	17	196,666	28	196,666	28

396.

Mr. Hill, in his book on "Public Water Supplies," Chapter 7, cites a large number of typhoid fever epidemics, giving the causes of the outbreak. In each case the cause has been the drinking of a sewage polluted water, or water carrying the germs of typhoid fever, or the ingesting of food which has been in contact with such water. In every instance the proof has been so clear as to leave no room for doubt. At the close of this chapter he says, "Thirty-five thousand deaths a year in the large cities of the United States are said to be due to typhoid fever alone, a disease the causes of which are fully understood, and which sanitarians declare is entirely preventable. The mischief making germ is usually taken into the system in drinking water, which has been contaminated with dejecta from other victims, residing many miles away. In some cases where there is a typhoid epidemic, the outbrak is traceable to the use of water from a well located near cess-pools; in others, to the common supply of a town, either a river or a lake."

These facts have now come to be generally recognized by sanitarians, and they have acted on this knowledge by purifying a supply of water whenever there is any cause for suspicion. The effect has been to decrease the death rate from typhoid, as shown by the tables given above. The death rate from the other preventable diseases has been decreased, as shown by the reports of the Michigan Board of Health. Then we can safely say that these recent great developments in sanitary science have resulted in the betterment of mankind, because of this prevention of disease and decrease in the death rate.

Yet we cannot limit the results to simply the prolongation of existence and the relief of physical suffering. An eminent sanitarian has said that "The relations between sociology and hygiene are extremely intimate, a fact which seems not sufficiently appreciated by the students of either subject." The results shown by the mortality records already given serve very important ends, but as this development of sanitary science continues, it is proved that it cannot be restricted in its effects to the physical life of man, but that it effects all his activities as a human being.

This conception of sanitation is coming to be recognized by the sanitarian. Mr. E. A. Parker, in the introduction to his work on "Practical Hygiene," says, "Taking the word hygiene in the largest sense, it signifies rules for the perfect culture of mind and body. It is impossible to dissociate the two. The body is affected by every mental and moral action; the mind is profoundly influenced by bodily conditions." Dr. Bowditch, in his address at the first meeting of the Massachusetts State Board of Health stated the third object of the board to be "To investigate the effects of the use of intoxicating liquors upon the industry, prosperity, happiness, health and lives of the people."

Marion Talbot, of the University of Chicago, in an article, "Sanitation and Sociology," published in the July number of the American Journal of Sociology, 1896, says, in speaking of the relations existing between sanitation and sociology:

"It was indicated as long ago as 1840, when Edwin Chadwick in his report on the sanitary condition of the laboring classes

of Great Britain came to the following conclusions:

That the youthful population, bred up under noxious physical agencies, is inferior in physical organization and general health to population preserved from the presence of such agencies.

That the population so exposed is less susceptible to moral influences, and that the effects of education are more transient than in a healthy population.

That these adverse circumstances tend to produce an adult population short-lived, improvident, reckless and intemperate, and with habitual avidity for sensual gratification.

That these habits lead to the abondonment of all the conveniences and decencies of life, and especially lead to the overcrowding of their homes, which is destructive to the morality as well as the health of large classes of both sexes.

That the removal of noxious physical circumstances, and the promotion of civic, household, and personal cleanliness is necessary to the improvement of the moral condition of the population, since sound morality and refinement in manners and health are not long found coexistent with filthy habits amongst any class of the community."

Marion Talbot concludes her article with these words: "Sanitation then will show what steps should be taken by society, individually and collectively, to secure the health of the race. Clean air, sunlight, wide streets, good pavements, public parks, nourishing foods, sanitary schools, public baths, adequate housing, are sanitary measures which are most effective in both

sanitary and social results if carried out at times when there seems no special cause for anxiety. The social reformer for his part will guide men to make some sacrifice of present comfort or enjoyment, to undertake labor and expense, so that all the forces of society may be united in bringing mankind as speedily as possible to the complete realization of its mighty and noble capabilities. Sanitation and sociology must go hand in hand in their effort to improve the race. The value of the relation which exists between them will be great in proportion as its importance is consciously and openly recognized."

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